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Lean Six Sigma for Small and Medium Sized Enterprises: A Systematic Review

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Abstract:	

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Lean Six Sigma for Small and Medium Sized Manufacturing Enterprises: A Systematic Review

Abstract

Purpose: The purpose of this paper is to explore the most common themes within Lean Six Sigma (LSS) relating to Small and Medium enterprises (SMEs) within manufacturing organisations and to identify the research gaps in the existing literature.

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Design/methodology/approach: Tranfeild et al's (2003) systematic review methodology was utilised encompassing three stages: Planning, Conducting and reporting/dissemination.

Findings: The literature revealed that there are many areas in which LSS has been utilised with varying successes. 52 journals have been reviewed and it has been concluded that although LSS is a powerful methodology, there are many gaps that exist in the literature and further research is needed to address these in the field of LSS.

Practical implications: It is vital that LSS practitioners are fully aware of the benefits, limitations and impeding factors when implementing a LSS initiative. Therefore, this paper could provide valuable insights to ensuring maximum value is obtained from LSS implementation in SMEs.

Research Limitations: The papers included in the systematic review were peer-reviewed papers available in English. Due to these limitations, relevant papers may have been excluded. Moreover, the authors have excluded all conference and white papers for their inclusion in this study.

Originality/Value: This systematic review identifies research gaps in the current literature and highlighting areas of future research which will be beneficial to many SMEs in their pursuit of value optimisation.

Keywords: Lean, Six Sigma, Lean Six Sigma, SMEs, Systematic review

Paper type: Literature review

Introduction

In today's competitive environment, businesses are continuously under pressure to improve their organisational performance. Standing still can be perceived as failure and even making excess profits that have not exceeded last year's targets can be considered as underperforming. Businesses have never before been under such pressure to demonstrate to shareholders and the market how well they are performing. Companies are continually examining their strategies and their ability to execute them so as to ensure that the business is being navigated in the best possible way to maximise shareholder's wealth, both at present and in the future. There are many competing business process improvement methodologies that business leaders can utilise to improve the efficacy of their operational, financial and strategic performance. One such business process improvement methodology adopted by many world class corporations is Lean Six Sigma (LSS). LSS is the fusion of two most powerful process excellence methodologies namely Lean and Six Sigma.

The Lean methodology was derived from the Toyota Production System (TPS) developed by Taiichi Ohno shortly after the Second World War in Japan in the 1940s (Ohno, 1988). It aims to allocate activities into two main categories, namely Value Add (VA) activities and Non-Value Add (NVA) activities. VA activities are all activities that the customer would be willing to pay for. It is associated with activities that transform the product from its initial form to the final product or service that is

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delivered to the customer. NVA activities are activities that should be considered as waste, or Muda as it was known in Japan (Womack et al., 1990).

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Lean is primarily focused on reducing cycle time to bring a reduction in lead time to the customer. Lean was highly popularised after the publication of the book “The Machine that Changed the World” by Womack in 1990. There are many challenges in adopting the Lean methodology. The lean methodology uses five stages which start with identifying value. When this has been done the next steps are map the value stream, create flow, establish pull and finally seek perfection. The process then starts again. The goal is to remove non-value activities from the process. One of the challenges in Lean is developing a culture that will accept and sustain the use of the tools and techniques required within this methodology.

Six Sigma is a methodology developed by Bill Smith in the mid-1980s who was a reliability engineer working for Motorola. Although the methodology was created in the mid-1980s, Six Sigma became popularised in 1995 by General Electric’s CEO Jack Welch. Welch had witnessed great success when the methodology was implemented in General Electric and concluded that this is the business strategy to be utilised for continuous improvement efforts. Welch championed this methodology and was proud to tell the world of the efficacy of the Six Sigma problem-solving methodology by taking it to the strategic level as well as the operational level across the business.

The method focuses on reducing variability of the inputs in a system with the ultimate aim of reducing variability of the outputs. This should reduce the number of defects or errors in the process of concern. The methodology of Six Sigma is very structured and utilises a five stage framework to improve the process known as DMAIC. Firstly in the Define phase the team must define the problem. This includes stating what is in and out of scope and having a common understanding of what it is that must be improved. The Measure phase is to ensure that the problem at hand has been quantified. This will help to ascertain if any improvements have been realised when the project is complete. The Analyse phase provides a deeper analysis of the problem. This phase will elucidate possible connections and correlations between various process variables. The Improve phase will concentrate on applying improvements to the process and ensuring that the process is moving to a more desirable state. The Control phase ensures that the process is constantly monitored and that processes are put in place to highlight the state of the process to enable timely intervention if required.

Lean and Six Sigma both have their own set of tools and techniques that can enhance a company’s objectives for value and profit enhancement. The two philosophies may primarily approach improvements in a different way and use a different mind-set however they both have the common objective of providing process performance optimisation, value enhancement and increased customer satisfaction. As a result of an acknowledgment among certain groups, books started to be released in the early 2000s relating to the combination of Lean and Six Sigma such as “Lean Six Sigma” (LSS) by M. L. George (George, 2002). By combining the two methodologies into a single philosophy that will approach process improvement from more than one perspective, there is an opportunity to deliver more value creation than being bound to one methodology alone. Applying Lean in isolation cannot statistically monitor processes to achieve stability and applying Six Sigma in isolation cannot eliminate all streams of waste from a business. However, by integrating the two

most powerful process improvement methodologies, more improvement streams become apparent and a greater number of options are available to provide value creation.

The Lean Six Sigma (LSS) approach uses the DMAIC framework and one may combine the tools of Lean and Six Sigma within this framework for problem-solving scenarios. The LSS tool box allows for a more rounded and less restricted approach to improvement. Some authors have argued that the combination of Lean and Six Sigma will have its difficulties. Others have suggested that it is a good strategy. Given the fact that Lean Six Sigma is very much a reality in today's continuous improvement strategy, there have been authors who have attempted to develop an integrated framework to execute the combined methodology (Antony et al. 2016, Kumar et al. 2006, Cheng and Chang, 2012; Hilton and Sohal, 2012).

Small and Medium Sized Enterprises

SMEs are vital to the economy of a country. According to the National Federation of Self Employed and Small Business Ltd (fsb), the definition of a Small firms ~~is~~^{are} considered to be a firms with no more than 50 employees (fsb, 2018). A

~~A Medium sized company~~^{SME is defined as a company with more than 50 employees and no more than 250 employees} by the Organisation for Economic Co-operation and Development (OECD). ~~is a company employing no more than 250 employees.~~ This number can change from country to country but 250 is the accepted figure in Europe.

According to Federation of Small Businesses (2018), it can be seen that in the United Kingdom, SMEs accounted for 99.9% of all business. SMEs can present a special suite of challenges when implementing continuous improvement methodologies. These challenges can range from resource issues to leadership styles. SMEs are the largest employer of personnel. SMEs employ 15.7 million in the UK which represents 60% of all private sector employment in the UK. SMEs act as suppliers to large organisations and therefore the "footprint" of SMEs is much larger than may be seen at a first glance. Moreover, due to the growing importance of supply chain management issues, SMEs should provide high quality products or services at low cost to larger firms.

SMEs of any country possess a strategic importance in economic growth because of their considerable contribution in terms of production, sales and development. SMEs contribution to world economy can be judged from the following (Morrison et al, 2003): small businesses in the US contribute to 99.65% of employment (Small Business Administration, 2005); small businesses add to 96.38% of non-agricultural industries in Australia (Australian Bureau of Statistics, 2003); and in the European Union, only 1% of businesses have more than 50 employees (Department of Trade and Industry, 2000).

It can be seen from the above analysis on SMEs that they are a very important part of the economy. They are also the largest employer bringing jobs and security for the majority of people in the countries mentioned above. These make SMEs vital to the economy and, therefore, special consideration and analysis should be performed on SMEs to further understand their continuous improvement journeys and factors affecting the success and failure of implementation and sustainability. It must be acknowledged that to truly design a continuous improvement strategy for SMEs, there must be an increased understanding of the environment that SMEs experience.

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SMEs exist in a very dynamic environment and changes can occur within very short time scales. SMEs can start and close down relatively quickly. There are a variety of reasons for their closure, including: lack of forward planning, cash flow problems, inability to capture and manage innovation, lack of investment at the right time, lack of business experience, and little or no external help. The aforementioned points can be stated as the weaknesses of SMEs. On the other hand, SMEs do have some strengths such as effective and open communication channels, low resistance to change, people orientation company-wide awareness, functional integration and employees adopting a natural responsibility for quality (Ghobadian and Gallear, 1997). The following table shows the strengths, weaknesses and challenges experienced by SMEs.

Strengths	Weaknesses	Challenges
Flexible and hence change can be introduced fairly quickly	Low degree of standardization and formalization	State of the economy
Flat with few layers of management and fewer departmental interfaces	Focus is on operational matters rather than planning	High insurance costs can have a huge burden on SMEs.
Top management highly visible and hence provide leadership by example	There are chances that management lay off employees when the work becomes superfluous. This makes SMEs work harder to retain a high calibre staff	The lack of lending from banks can affect the operations of SMEs greatly and can disrupt their supply chain
Rapid execution and implementation of decisions	Responsible for many facets of the business and many decisions. Decisions are generally made for short-term profitability	Continuous improvement strategy ironically may not be at the top of the priority list when survival is in the forefront of their mind
Training likely to be focused	Lack of skills, time and resources	No specified training budget
Loose and informal working relationships and absence of standardisation	Formation of strategy process is intuitive rather than analytical	Employees do not know their company strategy due to poor communication
Likely to deploy improvements quickly and gain rapid benefits	Adamant and dictatorial nature of owner can damage new initiatives	Continuous Improvement strategy has no alignment with business objectives of the organisation
Can apply for small grants from government for developing skills and expertise	No incentive or reward programs in many cases due to budget and resources constraints	Without any incentive or reward schemes in place, continuous improvement would not flourish

Table 1 Strengths, Weaknesses and Challenges of SMEs

Source: (Antony et al. (2008), Antony et al. (2005)

Leadership is very important is deploying continuous improvement efforts (Antony et al., 2010). Many leaders may not put continuous improvement as a priority as they only are concerned with short term gains at the expense of the longer strategic goals of improving the business. A few researchers (Antony, 2016; Snee, 2010) considered LSS as a top-down initiative, where the decision to implement LSS has to start from the top management, where they (1) communicate to the people

in the organisation about the urgency for implementation of LSS, (2) identify projects that can have a good impact on the organisation or on customers, (3) selecting the right people for working on the projects so that the projects are completed successfully, and (4) monitoring the progress of projects and providing necessary support in implementation. While top management should provide strategic and transformational leadership, LSS also needs leadership at execution and project management level from mid-management. Leadership at all levels needs to be consistent, in order to face and resolve the deployment issues [\(Laureani et al., 2012\)](#).—[This highlights one of the challenges for implementing LSS. A company that does not have effective leadership will have a big weakness when considering LSS as a way forward for value enhancement.](#)

Methodology

To fully appreciate the work that has gone before any study, it is necessary to analyse the existing literature (Booth et al, 2012). This will be done by performing a systematic literature review. A Systematic Literature Review is a methodology to systematically research work in a given field and to clearly evaluate and synthesise the findings in a reproducible way (Thomas et al, 2004). Tranfield et al (2003) also highlights the importance of performing a systematic literature review to ensure a structured, logical and clear approach to researching a subject.

When performing a systematic literature review it has the effect of elucidating the myriad of research that has gone before and shows the breadth and depth of the syntheses that has taken place already in the specific area of interest. This will facilitate identifying any gaps or weaknesses in the previous analysis and help to take the current understanding of the topic to a new level by contributing something new and original (Jesson, 2011).

Approach and phases

This paper will utilise nine stages for executing the systematic literature review. These nine stages can be grouped into three broad phases dependent of their function within the review. The phases are:

- Planning the review
- Conducting the review
- Reporting the review

This research process structure has been adapted from several academic sources including Tranfield et al (2003), Okoli and Schabram (2010), Thomas et al (2004) and Saja Ahmed et al (2014). This is shown in Figure 1.

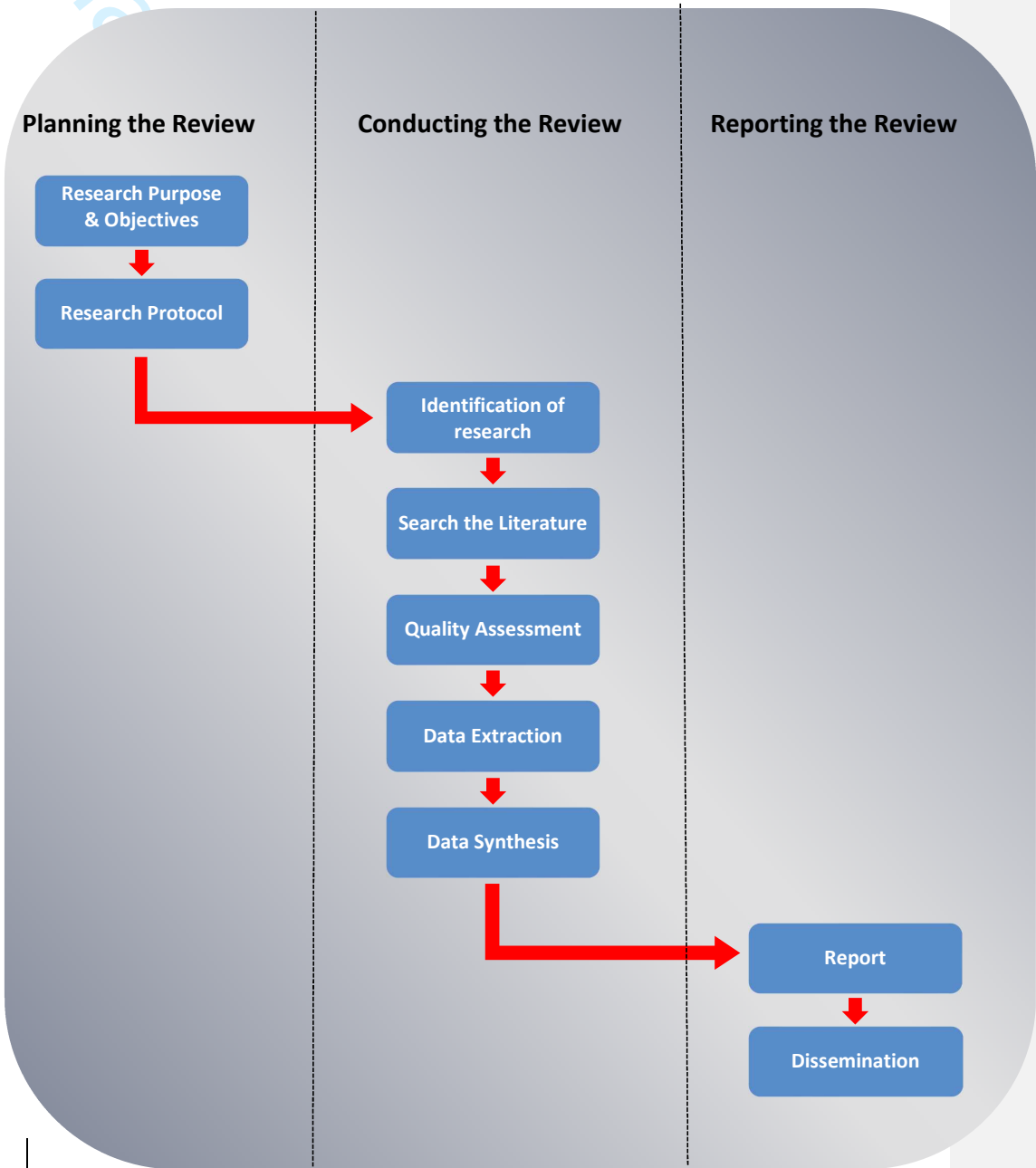


Figure 1 Summary of systematic review methodology (Adapted from Transfeild et al (2003), Okoli and Schabram (2010), Thomas et al (2004) and Saj et al (2014))

The stages for the systematic review within the three phases are:

- 1) Research purpose and objective: It is important to clearly state the purpose and the objective of the systematic literature review.
- 2) Develop a research protocol: The protocol is essential because it contains search criteria, scope and quality assessment of the research. This will help ensure that the review is targeted correctly and the results are of the appropriate standard.
- 3) Identification of research: This is when key words and search strings are defined to ensure the study can be replicated.
- 4) Search the literature: The literature is then searched using the defined strings within the defined sources e.g. journals. The papers are retrieved to be studied further.
- 5) Quality assessment for identified studies: Each article should be assessed depending on the methodology utilised and the quality of the contents.
- 6) Data extraction: The literature that meets all the requirements and quality standards should be recorded and isolated. The details of these should be recorded in an appropriately designed spreadsheet
- 7) Data synthesis: This is when techniques are used to analyse the data from the selected literature. This process could be qualitative or quantitative or a combination of both techniques.
- 8) Report: The process of the systematic literature review including synthesis and further suggested areas of research must now be reported highlighting any areas of weakness of the study.
- 9) Dissemination: The work performed on the systematic literature review should be published in an academic journal to share the findings and further enrich the existing body of knowledge in the field.

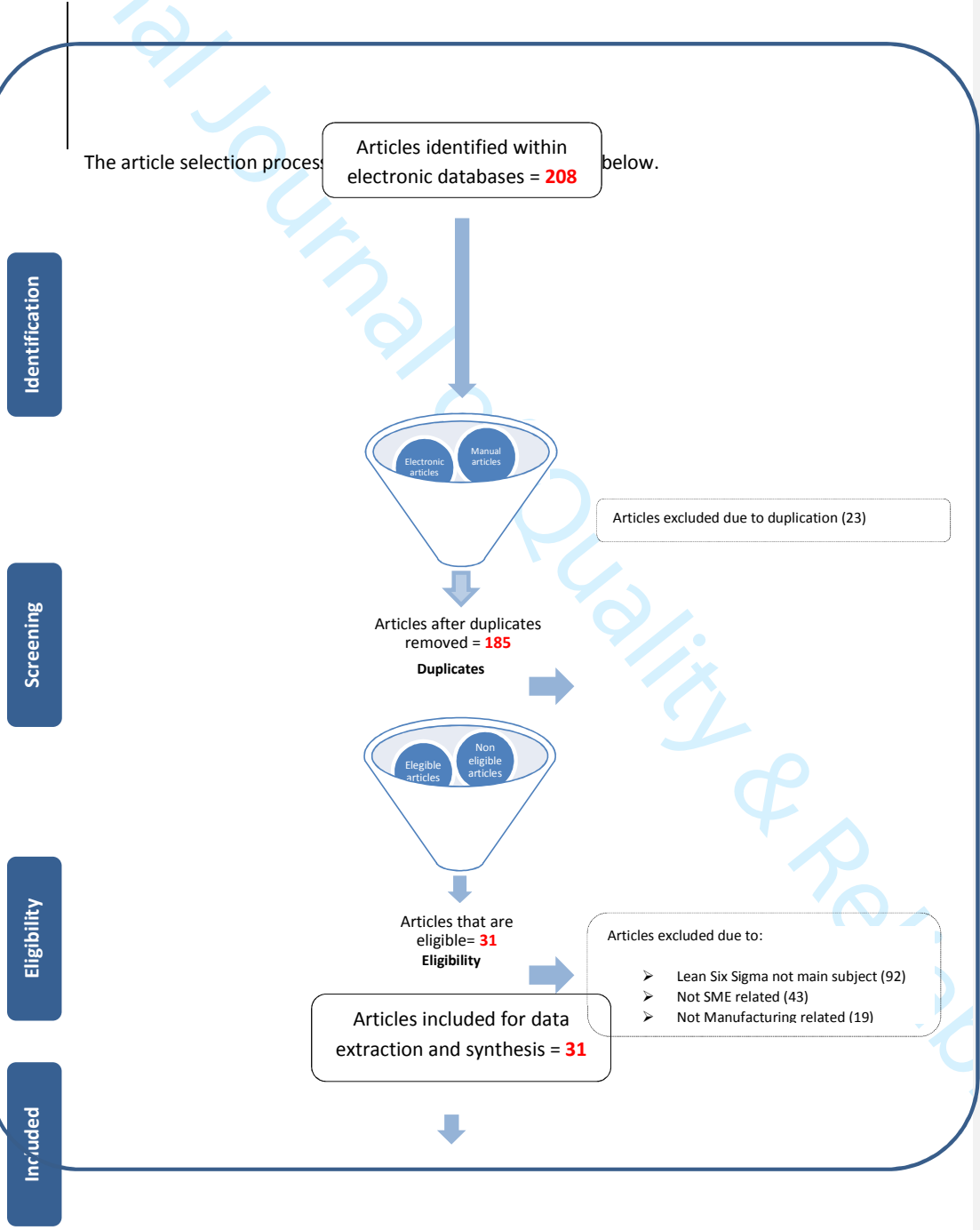


Figure 2 Article selection process

Planning the Review

The purpose of this research is to perform a systematic literature review of articles published in refereed academic journals in Lean Six Sigma within the small and medium sized enterprises (SMEs) context to elucidate the most common themes that prevail in this area. This will highlight gaps in the themes identified and expose areas within Lean Six Sigma that may be inhibiting optimal value creation from a company's improvement strategy. This paper will highlight gaps in the current literature and suggest areas of future research that will be useful in the Lean Six Sigma for SMEs body of knowledge.

The search was performed on 42 academic journals [from the Association of Business Schools \(ABS\) Journal Guide 2015 Edition](#). The search which encompassed using eight databases. ~~The journals were determined by the journal ranking list in the International Guide to Academic Journal Quality (ABS, 2015; Harzing 2012).~~ The databases utilised were SpringerLINK(SHEDL), Business Source Premier, Science Direct Freedom Collection (NESLi2), Proquest SciTech Collection, Wiley online library full collection (NESLi2), Sage Premier 2014 (SHEDL), Emerald Insight and Pro Quest Scitech collection. There were criteria used to limit the scope of the search and these criteria are shown in table 2.

Included	Excluded
Articles published between 2000 and 2016	Articles published before 2000 and after 2016
Articles published are peer reviewed journals	Articles published in non-peer reviewed journals
Papers related to manufacturing	Service and non-manufacturing papers
SMEs	Large organisations
Academic journals	Books, magazines, websites, conferences, technical reports etc.
English language	Non-English language

Table 2 Scope of research

Conducting the Review

It is vitally important to ensure that the search strings used for the research is chosen correctly (Tranfield et al, 2003). The search strings used to identify papers of interest are: ("SME" OR "SMEs") & "Lean Six Sigma". There were a number of restrictions in place to limit the scope of this research. The amount of research published can make any meaningful research very difficult which is one of the main reasons why the scope of the research has to be defined (Jesson et al, 2011). This message is echoed by other authors who state the scope is crucial to ensuring the review is concise and relevant (Booth et al, 2012). There will be limitations to any research due to the vast amounts of journals that exist which is why providing criteria is important to eliminate studies that do not fit with the specific research of interest (Okoli, 2010). The scope of the project is very important to focus in on points of interest within a field of study (Hart, 1998). The scope of this research is defined in table 2 above. There were a number of journals excluded from the study because not all the criteria were met during the review process. [The journals were excluded because these papers don't met the criteria.](#)

The quality of the studies identified must also fit with the research (Thomas et al, 2004), therefore, papers were only included when the appropriate journal rating was grade one and above. It is very important to acknowledge the review process should be a systematic, explicit and reproducible piece of work that reflects what has been published within the scope defined (Fink, 2010). The work should be free from bias selection but this can be very difficult to totally eradicate no matter how explicit the procedures (Hammersley, 2013). It is noticed that there were no journal articles on Lean Six Sigma published before 2003 (Alibliwi et al (2014). A breakdown of the number of relevant papers identified with their respective journal is shown in table 3. It can be seen that there were 31 papers identified that met the scope and quality criteria.

Journal Name	Quantity of Relevant Papers
Production Planning and Control	3
Journal of Manufacturing Technology Management	1
International Journal of Quality and Reliability Management	5
International Journal of Lean Six Sigma	8
Business Process Management Journal	1
The TQM Journal	1
Spring Science and Business Methods	1
International Journal of Production Research	3
Quality and Reliability Engineering International	2
Journal of Operational Management	1
Journal of Operations Research Society	1
Quality and Quantity	1
The International Journal of Advanced Manufacturing Technology	1
Arabian Journal for Science and Engineering	1
Journal of Engineering Design and Technology	1
Total	31

Table 3 Journal list with quantity of relevant papers

Reporting the Review

After careful analysis and syntheses of the research results, a number of key findings and trends have been identified that meet the criteria specified earlier. These findings will now be disseminated and illustrated below.

Growth of LSS publications in the SME Manufacturing sector

There has been an increase in the number of LSS publications in academic journals for SMEs in the manufacturing area since 2008. This is shown in Figure 3 below. The trend shown started with a paper by Thomas et al on a SME manufacturer utilising LSS. It can be seen that there was a relatively high number of publications in the years 2011 and 2013 with five and seven publications respectively. The number is still low which highlights the need for further research in the LSS field within SMEs in the manufacturing area. The relatively low papers in this area is still adequate for

conducting a systematic literature review because it can highlight areas that need further research to elucidate the environment that exists within the SME manufacturing arena. Moreover, there is not an agreed lower limit to how many papers are required to conduct a systematic literature review (Albliwi et al, 2015).

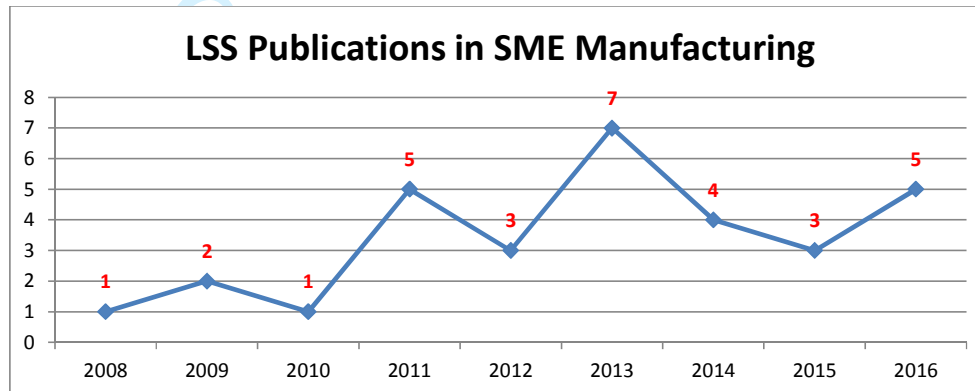


Figure 3 LSS Publication quantities in the SME Manufacturing sector

Distribution of publications across different countries

Analysing the distribution of publications of LSS for SMEs in the Manufacturing sector has resulted in 11 countries being identified. This is shown in figure 4. The UK has registered the largest number of publication with 25.8% (8 papers). This is followed by India with 22.6% (7 papers). Netherlands, Australia and Malaysia have 9.7% (3 papers). Sweden has 6.5% (2 papers). Belgium, China, USA, Brazil and Turkey have 3% (1 paper).

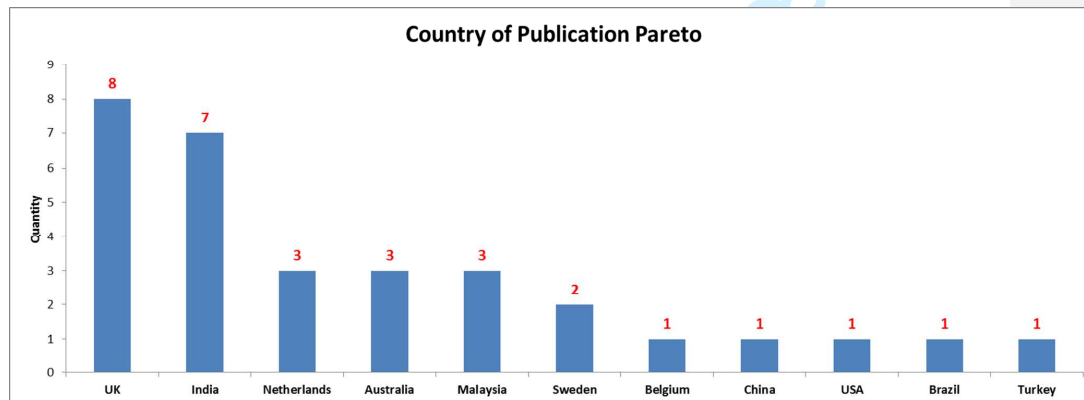


Figure 4 Pareto Analysis on the country of publications for LSS in Manufacturing SMEs

Themes

This research has highlighted that there are common threads that connect the papers studied. These themes transcend the companies involved in the studies and demonstrate that although the various papers studied may have their differences dictated by the type of challenges the relevant company may face, they do have several similarities that are common. These themes are shown in Table 4 below.

Theme	Number of Papers
Tools and Techniques	18
Benefits	15
Motivation	17
Challenges	14

Table 4 Themes of LSS in Manufacturing SMEs

The themes identified above have particular resonance in the LSS manufacturing industry within SMEs. These will now be looked at more closely.

Theme 1: Tools and Techniques

An analysis of the most common tools and techniques that have emerged from the study is shown below in figure 5. It can be seen that the top six tools of LSS appeared in the current literature are Cause and Effect, Value Stream Mapping (VSM), Pareto, Control chart, 5S and Process Mapping. These represent almost 50% of the tools and techniques utilised across the studied papers.

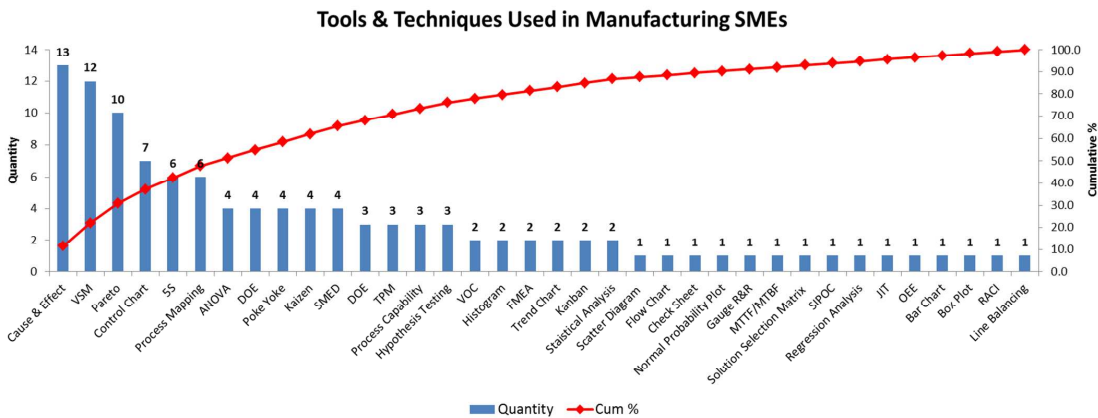


Figure 5 Tools and Techniques usage Pareto within Manufacturing SMEs

These top six tools and techniques have been used in the LSS improvement strategy and appear to be the favourite ones to be utilised by SMEs. Complex statistical analysis techniques tend to be

avoided because of the difficulty in methodology and understanding behind them. It has been argued that Six Sigma tools and techniques tend to be avoided because of the lack of understanding in the statistical tool kit offered within the Six Sigma problem solving methodology (Thomas et al, 2008). The top six tools identified are relatively simple and intuitively easy to use in a continuous improvement journey.

There are a number of tools that do not feature or seldom feature in the identified Pareto shown in figure 5. Tools such as Quality Functional Deployment (QFD), Regression Analysis, Hypothesis testing and Design of Experiments (DOE) tend not to be used. As previously suggested these tools tend to require a deeper appreciation of problem solving and, therefore, are not used as often as they could be. There is an argument that by using techniques like these could disengage the workforce and have a negative effect to the overall continuous improvement journey. These techniques can be extremely powerful and can solve real practical problems. For example, DOE is a very useful and robust technique and if taught properly and applied correctly could help the continuous improvement strategy greatly. One of the challenges is to engage the workforce with techniques such as DOE and to find time to perform them. There is a case that further research needs to be done to develop a suite of tools that would benefit SME manufacturing companies that would engage the workforce while delivering tangible benefits.

Theme 2: Benefits

The analysis of the relevant papers studied has shown that there are numerous benefits from the implementation of LSS in SMEs. These benefits are shown below in figure 6. The top five benefits identified represent almost 80% of the benefits reported. These are:

- 1) Reduced operational costs
- 2) Improved Quality
- 3) Increased throughput
- 4) Reduced Downtime
- 5) Increased efficiency

Other benefits mentioned in the literature are reduced lead time, increased profit-margin, reduced waste/scrap and increased morale.

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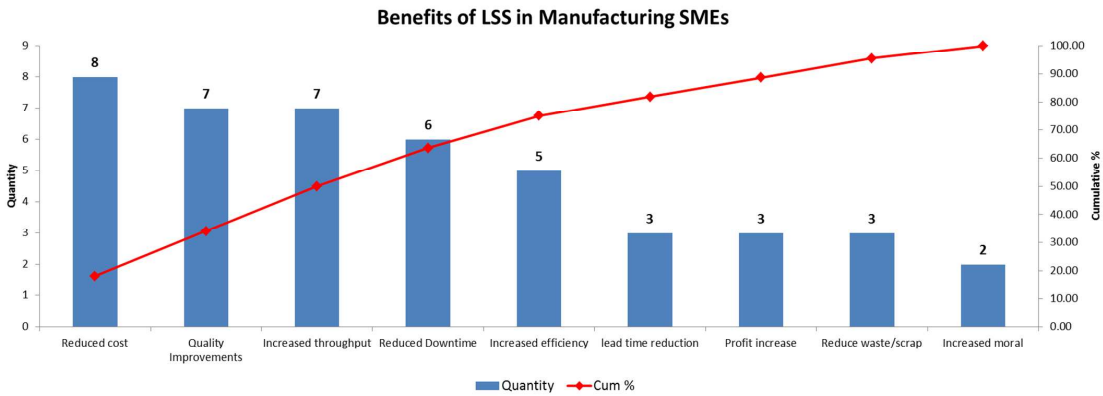


Fig 6 Benefits of LSS implementation in Manufacturing SMEs

It has been observed that all the papers identified in the SME manufacturing area have not reported failure in the LSS implementation process. There may be various reasons why this would happen. One reason is that it takes valuable time and resource to produce a paper and there would be little appetite to publish failures. Another possibility is that the various Journals are exhibiting selection bias when selecting which articles to include because they only want to report success (Albliwi et al, 2015). This would be a significant omission if the hypothesised reasons are true. Including failed studies within journals would be advantages and would provide insights into the efficacy of the LSS implementation strategy (Albliwi et al, 2015). There are important lessons and insights to be learned from failure as well as in success.

Theme 3: Motivational Factors

Analysis of the relevant articles has suggested that there are many motivational factors that inspire manufacturing SMEs to implement LSS. These are shown in figure 7 below. The factors that make up almost 80% of the reasons are improved efficiency, increased profit-margin, improved quality, reduced costs and improved customer satisfaction. Other motivational factors identified are: reduced waste, reduce lead time, improved organisation culture and eliminate non-value add activities.

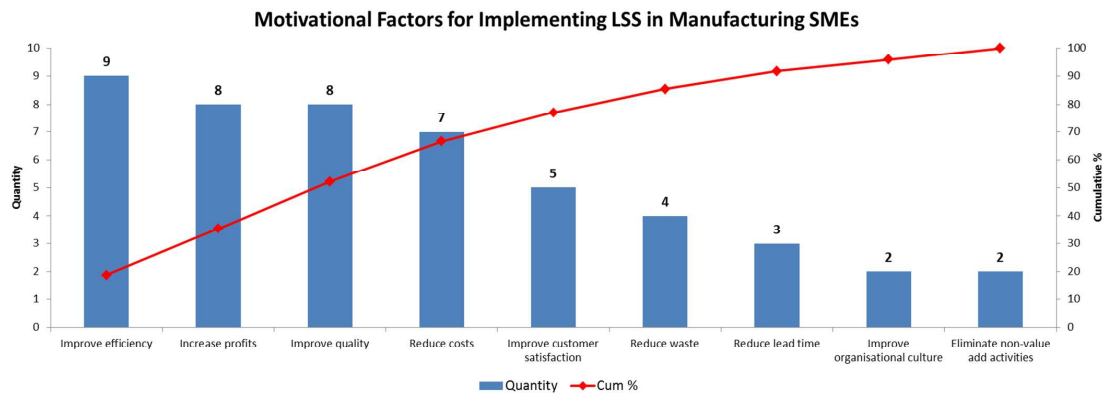


Fig 7 Motivational Factors for Manufacturing SMEs

It can be seen from figure 7 that the motivational factors are very operational. They are very much concerned with saving money and increasing profits and all the other factors are geared around this. A possible exception to this is "improved customer satisfaction" which is outwardly looking from the organisation. There is little indications of motivational factors relating to improving organisational culture or creating a business for continued personal growth and learning. Only 4.17% mentioned that the motivation was related to organisational ~~culture~~ ^{culture}. The motivation is heavily biased towards operational efficiency and financial performance. There is very little evidence of strategic motives for implementing LSS in the organisation. Perhaps this is understandable due to the issues that SMEs have to deal with explained earlier.

Theme 4: Challenges

The challenges presented when implementing LSS in manufacturing SMEs are shown in figure 8. It can be seen that almost half the issues are encapsulated in the top four reasons. These reasons are Lack of time/resources, resistance to change, poor leadership and absence of LSS road map/model for deployment.

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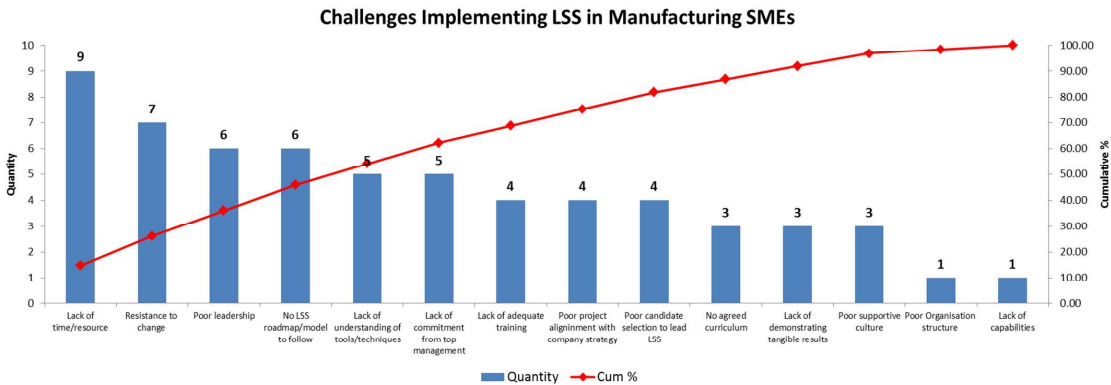


Figure 8 Challenges Implementing LSS in Manufacturing SMEs

The most common challenge for manufacturing SMEs is lack of time and resources (financial, human, time etc.). Companies are very busy trying to deliver their core business requirements. These are the core competences that the business is good at and, therefore, they will have targets to achieve and deadlines to meet. This can take up time and resource leaving little resource to invest in quality and process improvement initiatives. It is very unlikely that an SME will have a dedicated continuous improvement infrastructure to devote complete attention to the strategic direction of the continuous improvement efforts and to take the business to the next level in terms of quality, productivity, efficiency and cost saving.

Research Gaps and Agenda for Future Research

There are various gaps in the existing literature that have been identified and outlined in the following section.

Lack of a standardised Toolkit

There are a great number of tools and techniques embedded in the LSS methodology. These are used to varying degrees throughout industry and the effective use of these tools can determine if improvement will be successful or not. This is extremely important to the organisation wishing to utilise LSS as a way to strategically gain competitive advantage in the market place. However, SMEs have their own set of issues and challenges that may not be able to be generalised throughout all of the business community. Therefore, it would be of great benefit if a set of tools and techniques could be identified that SMEs could specifically use to aid attainment of their goals for continuous improvement. By acknowledging the SME's unique issues a more practical and useful toolkit could be developed which is missing in the current literature. Many consultancy companies who deliver training courses on LSS usually carry out a cherry-picking exercise regarding the selection of tools and techniques. The authors argue that there could potentially be three levels for the application of tools and techniques in a LSS methodology including basic, advanced and very advanced. The basic level may include some of the basic tools of quality improvement such as process mapping, project charter, root cause analysis, cause and effect analysis, waste analysis, etc. The advance level may include some of the more technical tools of problem solving such as SMED, Poka Yoke, FMEA, 5S practice, Voice of the Customer (VOC) analysis etc. The very advanced level may include some of the

statistical tools such as Hypothesis tests, Regression analysis, Analysis of Variance (ANOVA), Design of Experiments (DOE), etc.

Infrastructure for LSS deployment

LSS infrastructure can influence many attributes of an organisation such as flow of information, communication techniques and resource distribution. Without a proper, balanced and effective infrastructure, LSS projects cannot be executed by SMEs effectively. The Senior Management Team (SMT) must ensure that they invest appropriately to develop such infrastructure for sustainable deployment of LSS in SMEs. How many Green Belts and Yellow Belts are required for successful deployment of LSS in an SME environment? Do SMEs need Black Belts on a full time basis like larger organisations? How many project champions are required to carry out toll-gate reviews with project leaders? This is an unexplored area of research and requires further attention from both academics and industry.

Characteristics and qualities required for LSS project leaders in SMEs

Personality traits can have a huge effect on the success of LSS projects. To educate people on the theory of LSS concepts will require a specific set of skills. To lead a team and deal with the behaviour and attitudes of various team members during the course of the LSS projects will require a different skill set. Each individual has a set of capabilities that they use to navigate when delivering a successful project. What selections of traits are required for LSS Green Belts and Yellow Belts in an SME environment? It may be important that Green Belts should possess a good mix of hard and soft skills compared to LSS Yellow Belts who need more hard skills. If LSS Black Belts are desirable in an SME environment, what sort selection of attributes and traits should they require? How is a project champion in an SME environment selected? Being able to work with people from directors to shop floor workers is an important skill and can help with the delivering of LSS projects especially in the context of SMEs with resource and time constraints. This is another area which has never been addressed properly in the existing LSS literature for SMEs.

LSS deployment Road map/Model

When a company is trying to implement a continuous improvement strategy, it is always useful to have a road map or a model to follow. Due to the fact that SMEs have their own set of issues, a model designed for them would be greatly advantageous. A deployment roadmap or model which understands the issues and resource constraints would guide SMEs through their LSS implementation strategy and make the implementation journey more efficient and effective. Moreover, the roadmap/model should take into account the environment and the individual circumstances that prevail. Models that treat every situation as the same have limited use. There is no "one size fits all" solution. Research has shown that very few papers have talked about a LSS roadmap for SMEs and the existing roadmaps (Antony et al., 2016) are not user friendly and practical as they have been developed by researchers and academics with limited expertise and work experience in the field of LSS. This suggests that there is an immense need for the development of a practical and strategic roadmap for implementing and sustaining LSS in an SME.

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Other observations that this research has highlighted are that the literature has not acknowledged the following conceptual antecedents to continuous improvement:

Lean Six Sigma Prismatic Effect

The concept of Lean Six Sigma is that it is a methodology for improving processes by using a set of tools and techniques in a systematic fashion. This is a powerful concept and can bring gains to organisations around the world. It is interesting to acknowledge that the majority of the tools used in LSS were not originated at the inception of the Lean, Six Sigma or LSS methodologies. The most common tools used in LSS such as Pareto, Root Cause Analysis (RCA), Fishbone diagram, 5S, Design of Experiments (DOE), Statistical Process Control charts (SPC charts) and histograms were not invented within the LSS, Lean or Six Sigma methodologies. The conceptual diagram of LSS as a continuous improvement methodology consisting of Lean and Six Sigma is shown below in the LSS prismatic effect diagram in figure 9.

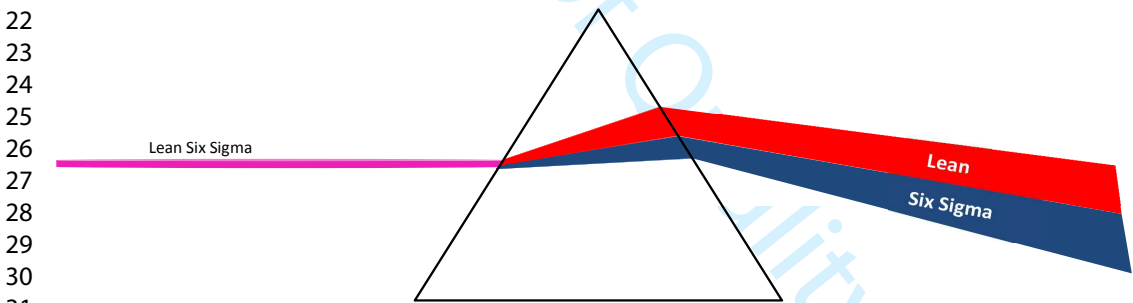


Figure 9 Prismatic Effect of LSS

It can be seen from the above diagram that LSS refracts into the two concepts of Lean and Six Sigma. By displaying LSS ,or any other improvement methodology, in this way highlights that there are other sub methodologies or basic elemental building blocks that come together to form the constituents of a methodology. These building blocks should be able to be assembled in any way the continuous improvement practitioner wants. This is a similar analogy to white light being composed of other colours of light.

The prismatic effect outlined raises an important question in the concept of continuous improvement. Why should any business choose to restrict their continuous improvement efforts to one improvement methodology? The end goal of continuous improvement is to increase process efficiency, process effectiveness, reduce cost and increase profit-margin. The chosen tool or technique or even methodology should be based on what is right for the situation that needs attention. Also, the capabilities of the business need to be taken into account. If the business has a lack of statistical skill or a lack of knowledge in a specific area this could render the improvement effort ineffective if there is an assertion that methodologies must be strictly adhered to in their entirety.

The best continuous improvement methodology to use is one which is not confined to one style of thinking or one methodology for moving forward. Continuous improvement should be flexible and adaptable to the improvement opportunity and be a confluence of different concepts if required. The improvement methodology should have cognisance of the resource, skill level and strategic objectives of the company. The continuous improvement practitioners who can adapt to the specific environment will have the better probability of success. Being a slave to one or two methodologies can restrict the improvement effort and the potential for value creation. Having a restricted mind set with a parochialistic view truly underpins the lack of understanding that the ultimate goal is value creation and helping with the delivery of the strategic and tactical goals of the company. However, there are no clear guidelines for SMEs to select suitable continuous improvement methodologies in the existing literature and there is a conspicuous gap as to what methodologies are to be selected against various problems in the business.

Using more than one methodology can increase the chances of value creation. Bundling concepts and tools together and labelling them as a specific methodology can be a limiting activity in the area of continuous improvement. Further research will need to be done to break down the barriers between methodologies to enable the right methodology and tool for the problem at hand to be utilised. This may be more important in SMEs than bigger companies. To obtain the best value from a company's continuous improvement efforts a company should strive to have a continuous improvement strategy that has a high plasticity. Continuous improvement plasticity is the ability of a company's continuous improvement strategy and efforts to adapt to the environment, resources and various other variables that prevail. It is the strategy that can evolve and adapt to the environment that will have more value than a strategy that is static and fixed and does not take cognisance of what is happening in the company with which it exists.

Barycentre and Occultation within Lean Six Sigma

The barycentre within LSS can be considered as the centre of gravity of the LSS efforts which will lie between the Lean and Six Sigma methodologies. Studying the interaction of the two dominant methodologies embedded within LSS can be extremely interesting. The two methodologies can be considered as forces within a company attempting to make positive changes and add value to the organisation. However, how these methodologies revolve or interact with each other and the company may not be a static problem but a dynamic set of interactions which changes with time. Figure 10 below diagrammatically illustrates a company which is equally engaged in both Lean and Six Sigma.

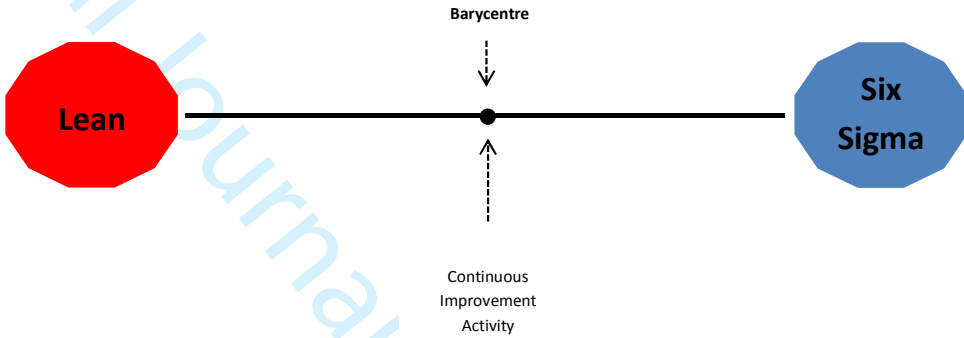


Figure 10 Barycentre of Continuous Improvement activities equally between Lean and Six Sigma

The diagram above shows that the company is equally engaged in both Lean and Six Sigma. It can be seen that the barycentre is positioned equally between these two forces of improvement suggesting that the centre of gravity for improvement is equally distributed between the Lean and Six Sigma methodologies. However, the company may find itself in a position where it is operating closer to one end of the spectrum of these two methodologies. If the barycentre is closer to the Lean end of the spectrum it would suggest that the focus of improvement would be on reducing non-value adding activities. If the barycentre is closer to the Six Sigma the dominant focus would be on reducing variability.

There could be circumstances where the company is operating extremely close to one end of the LSS spectrum where it is practically completely engaged in one methodology. In fact the bias could be so great that a process of occultation has occurred. This is when one methodology is being used so predominantly that it completely hides or removes the focus of other methodologies. In this case the antipodal point is reached.

Where the barycentre lies within LSS in the context of a company on a continuous improvement journey can have an impact on how the company adds value to the business. There may be situations where it is appropriate to have a strong bias at either extreme. It is the LSS practitioner who has a huge influence on how the company will progress with continuous improvement efforts. The LSS practitioner may subconsciously be biased towards a specific tools set and will try and force the use of these tools sets on to a situation which they are inappropriate for. Research is required to investigate where to place the barycentre of the continuous improvement efforts and how this barycentre may shift with time. Factors which may affect the barycentre are:

- The needs of the company.
- The skill level of the improvement team available.
- The skill level of the LSS practitioners in an SME.
- Priorities of the company.
- The nature of the problem at hand
- Type of methodologies at the disposal of the practitioner/company

- Organisational culture of the company
- Style of leadership and their vision for continuous improvement

Further research is needed to understand the continuous improvement barycentre and how to influence where it should lie in relation to the context of the improvement opportunity, company characteristics and the environment that prevails at the time. Improvement approaches must be synchronised with the facts and relevant variables and this can be dynamic with time.

Conclusion and discussion for further research

Organisations are under increasing pressure to maximise profits and increase shareholder value. Continuous improvement initiatives such as LSS have been used to help with this aim and have delivered some good results. SMEs are essential to the economy of governments and deserve to be studied in detail to gain insights into how they interact with LSS and to understand what special issues SME may have. SMEs contribute 60% of all employment and therefore, by understanding how LSS and SMEs interact will bring advantages to enable greater value extraction from the LSS methodology which will benefit SMEs and the economy as a whole.

It has been shown that within SMEs the main motivational factors are predominantly operational with the aim to increase quality, reduce costs and increase profits. This coupled with a lack of resource that SMEs suffer from can lead to a special environment that SMEs operate in when compared to larger organisations. Moreover, there are a number of gaps in the research of LSS within SMEs. A specific tool set for SMEs needs to be developed that acknowledges the environment that SMEs operate in. Also the infrastructure for SMEs that best facilitates LSS deployment will need to be considered taking into account the lack of resources that SMEs have. The characteristics of a LSS leader and a developed roadmap for deploying LSS within SMEs also need further research to optimise these areas within SMEs.

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